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(54) Latency-reducing bandwidth-prioritization for network servers and clients

(57) Communications bandwidth available to network servers and computers running client processes is allocated among connections available to those devices based on sets of priorities. Those priorities include type of information being retrieved, how fast user connections can receive information, which part of a document is being transmitted, user identity, stored indicia indicating importance of the document and the state of application processes running on said computer. Bandwidth is reallocated on an event driven basis upon arrival of a new request for retrieval, finishing sending information in response to a retrieval request, cancellation of a retrieval request, detection of the inability of a user connection to use all of the bandwidth allocated to it, a change of priority and timeout of a timer.

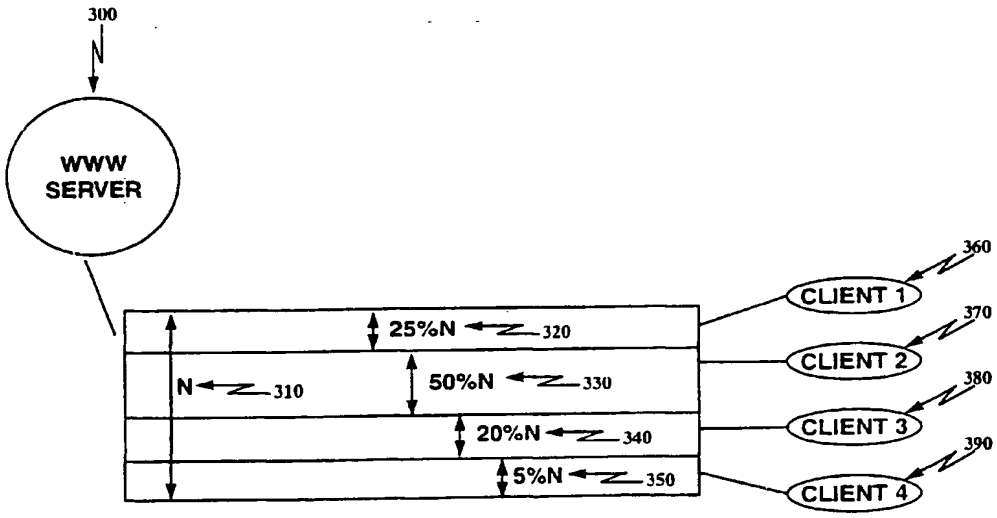

Figure 3

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to communication systems and more particularly to client server communication systems in which communications resources provided to a retrieval request or to a connection to a particular server can be adjusted to reflect priorities.

Description of Related Art

Accessing the content of servers on a network, such as the World Wide Web (WWW), is often agonizingly slow. Response time may be so slow that users cancel their request for a page and select another page, perhaps that of a competitor. Getting enough text to the user quickly so that he may begin reading is important to prevent him from canceling his request. Reducing the initial latency from request to delivery of readable text will result in a more satisfying browsing experience for the user.

Data compression is known. Various data compression algorithms may be employed depending upon the type of data (text, image, video, audio) to be transmitted. Fortunately, many if not most network servers employ compression. Unfortunately, the latency problems associated with retrieving server pages continue to grow worse with increasing network usage.

SUMMARY OF THE INVENTION

The present system provides apparatus, systems, methods and computer program products which will allow improved average response time in client server technology. This is accomplished by prioritizing the content of network pages and allocating server or client bandwidth accordingly. The prioritization scheme is driven by the need to render a viewable page as quickly as possible so that the user may begin reading it. In the prior art, all files that make up the final appearance of a WWW page (text, style sheets, graphics, audio etc.) are sent with equal priority. By using a prioritization scheme, it is possible to dramatically reduce the latency perceived by the user which, in turn, increases the perceived usability of the web site.

Two mechanisms facilitate this. First, the order in which information is displayed to the user "hides" some of the latency thus creating the perception of faster response time. Second, by monitoring individual connections it is possible to determine which connections are not currently utilizing the bandwidth initially made available to them. When this occurs, the unused bandwidth is allocated to all other existing connections which might be able to use it.

The same concepts can be applied to the client-side (the user) in one form by allowing the client to indicate to the server the speed with which the client will accept information. In another form, a client that has multiple browsers connected to respective multiple network servers can prioritize each connection to insure, for example, that the current browser window's connection is allocated more bandwidth than a minimized browser window's connection. This is not possible using the prior art since all connections are given the same priority.

The invention is directed to computer apparatus, such as that found at a server, for allocating communications bandwidth to a plurality of user connections. The apparatus includes a processor configured to allocate communications bandwidth to said user connections based on at least one set of priorities.

The invention is also directed to computer apparatus, such as that running a client process, for allocating communications bandwidth to a plurality of server connections based on at least one set of priorities.

The invention is also directed to a communications system operating on a network and having at least one server and at least one computer running a client process in which said at least one server or said at least one computer allocates bandwidth to a plurality of network connections based on at least one set of priorities.

The invention is also directed to methods for operating servers and clients to allocate bandwidth to connections based on at least one set of priorities.

The invention also relates to computer program products useful for carrying out the methods and for implementing the apparatus described.

The foregoing and other features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The object, features and advantages of the system of the present invention will be apparent from the following descriptions, in which:

Figure 1A illustrates a computer of a type suitable for carrying out the invention as either a client or a server.

Figure 1B illustrates a block diagram of the computer of **Figure 1A**.

Figure 1C illustrates an exemplary memory medium containing on or more programs usable with the computer of **Figure 1A**.

Figure 2A is an illustration of one exemplary form of implementing the invention using a network such as an intranet.

Figure 2B is an illustration of another exemplary form of implementing the invention using a typical internet arrangement.

Figure 3 is an illustration of bandwidth allocation from a network server to several clients.

Figure 4 is a database schema organized as an exemplary way for storing file-type priorities.

Figure 5 is a database schema of an exemplary way for storing current connection information, namely in an Allocated Utilization Table (AUT).

Figure 6 is a flowchart of a process to initiate dynamic bandwidth allocation by the server.

Figure 7A is a flowchart of a process for dynamic bandwidth allocation by the server.

Figure 7B is a illustration depicting the result of one iteration of the dynamic bandwidth allocation procedure of **Figure 7A**.

Figure 8A is a database schema organized as an exemplary way for storing client browser-status priorities.

Figure 8B is a flowchart of a process for client-side control of bandwidth allocation.

Figure 9 is a flowchart of a process for changing the priority of a connection after a fixed amount of data has been transmitted.

Figure 10A is a database schema organized as an exemplary way for storing a value representing the respective amount of data specific files need to have transmitted at high priority.

Figure 10B is a flowchart of a process for changing the priority of a connection after the variable amount of data indicated in **Figure 10A** has been transmitted.

Figure 11A is a database schema organized as an exemplary way for storing a list of customer passwords and the corresponding priority multiplier.

Figure 11B is a flowchart of a process for increasing the priority of a connection using the information contained within **Figure 11A**.

Figure 12A is a database schema organized as an exemplary way for storing a list of documents and their associated priority multipliers.

Figure 12B is a flowchart of a process for increasing the priority of a connection using the information contained within **Figure 12A**.

NOTATIONS AND NOMENCLATURE

The detailed descriptions which follow may be presented in terms of program procedures executed on a computer or network of computers. These procedural descriptions and representations are the means used by those skilled in the art to most effectively convey the substance of their work to others skilled in the art.

A procedure is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. These steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It proves convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like. It should be noted, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

Further, the manipulations performed are often referred to in terms, such as adding or comparing, which are commonly associated with mental operations performed by a human operator. No such capability of a human operator is necessary, or desirable in most cases, in any of the operations described herein which form part of the present invention; the operations are machine operations. Useful machines for performing the operation of the present invention include general purpose digital computers or similar devices.

The present invention also relates to apparatus for performing these operations. This apparatus may be specially constructed for the required purpose or it may comprise a general purpose computer as selectively activated or reconfigured by a computer program stored in the computer. The procedures presented herein are not inherently related to a particular computer or other apparatus. Various general purpose machines may be used with programs written in accordance with the teachings herein, or it may prove more convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these machines will appear from the description given.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1A illustrates a computer of a type suitable for carrying out the invention. Viewed externally in **Figure 1A**, a computer system has a central processing unit **100** having disk drives **110A** and **110B**. Disk drive indications **110A** and **110B** are merely symbolic of a number of disk drives which might be accommodated by the computer system. Typically, these would include a floppy disk drive such as **110A**, a hard disk drive (not shown externally) and a CD ROM drive indicated by slot **110B**. The number and type of drives varies, typically, with different computer configurations. The computer has a display **120** upon which information is displayed. A keyboard **130** and a mouse **140** are typically also available as input devices. Preferably, the computer illustrated in **Figure 1A** is a SPARC workstation from Sun Microsystems, Inc.

Figure 1B illustrates a block diagram of the internal hardware of the computer of **Figure 1A**. A bus **150** serves as the main information highway interconnecting the other components of the computer. CPU **155** is the central processing unit of the system, performing calculations and logic operations required to execute programs. Read only memory (**160**) and random access memory (**165**) constitute the main memory of the computer. Disk controller **170** interfaces one or more disk drives to the system bus **150**. These disk drives may be

floppy disk drives, such as **173**, internal or external hard drives, such as **172**, or CD ROM or DVD (Digital Video Disks) drives such as **171**. A display interface **175** interfaces a display **120** and permits information from the bus to be viewed on the display. Communications with external devices such as a network can occur over communications port **185**.

Figure 1C illustrates an exemplary memory medium which can be used with drives such as **173** in **Figure 1B** or **110A** in **Figure 1A**. Typically, memory media such as a floppy disk, CD ROM, or Digital Video Disk will contain the program information for controlling the computer to enable the computer to performs its functions in accordance with the invention.

Figure 2A is an illustration of one exemplary form of implementing the invention using a network such as an intranet. The network **200** is typically an internal organizational network that connects the client computing device and at least one WWW server.

Figure 2B is an illustration of another exemplary form of implementing the invention using a typical Internet arrangement. The client computing device **250** connects via one network with the client's Internet Service Provider (ISP) **240**. The ISP **240** then connects via the Internet **230** to a WWW server **260** requested by the user.

Figure 3 is an illustration of bandwidth allocation from a network server to several clients. The network server **300** has a predetermined amount of bandwidth N **310** which it must divide **320**, **330**, **340** and **350** between multiple clients **360**, **370**, **380**, and **390**. Note that the bandwidth allocation each client receives varies. This variance reflects the bandwidth allocation of the prioritized client connections as described in **Figures 4-7**, hereinafter.

Figure 4 is a database schema organized as an exemplary way for storing file-type priorities. The table has two columns: File Type **400** and Priority **410**. An HTML file **420** will have a priority of 4 (**430**). A style sheet **440** will have a priority of 3 (**450**). Priority 2 **470** is reserved for future use. GIF **480** and JPG files **490** both have priorities of 1 (**485** and **495**).

Figure 5 is a database schema organized as an exemplary way for storing connection information about clients actively involved in retrievals. The Allocation Utilization Table (AUT) **500** shown is a data structure used to track the status of each active current connection. For each such active current connection the file name **510**, priority **520** (determined from **Figure 4**), allocated bandwidth **530**, utilized bandwidth **540**, and a recalculation Boolean variable **550** are stored in the AUT. The AUT is used to provide the data for the bandwidth re-allocation algorithm of **Figure 7**. In rows **560** and **565** it should be noted that the allocated bandwidth exceeds the utilized bandwidth. When this difference exceeds a threshold, the recalculation variables are automatically set to FALSE to prevent re-allocation of more bandwidth than the connection can utilize.

Figure 6 is a flowchart of a monitoring procedure to initiate dynamic bandwidth allocation by the server. A continuous monitoring loop **600** responds to events affecting bandwidth allocation. One event is a new request (**605**) for bandwidth. Normally, this will occur when an HTTP GET command is received by the server. Following a new request **605** the requested file name and its associated priority based on its file-type are placed into the AUT and the recalculation variable is set to TRUE (**610**). Then the recalculation of bandwidth allocation algorithm is invoked (**650**) which updates the AUT, then the AUT is used to provide parameters to the bandwidth allocator (**655**) and the monitoring loop resumes **600**.

An event indicating the completion or cancellation of a transmission connection (**615**) will remove the connection from the AUT (**620**). Then the recalculation of bandwidth allocation algorithm is invoked (**650**) which updates the AUT, the AUT is then used to provide parameters to the bandwidth allocator (**655**) and the monitoring loop resumes (**600**).

An event indicating that the client is not utilizing all of the allocated bandwidth occurs when the average throughput of data (calculated, for example, using the number of ACKs received per unit of time) falls below the allocated bandwidth maximum data rate (**625**). Various protocols from in the prior art, including Stop-And-Wait Link Utilization and Sliding-Window Flow Control, can be used to calculate the actual data rate. For example, one might add the packet lengths of a number of packets sent over a period of time and divide the total by the length of the period of time to determine effective throughput, or actual data rate. That value is then stored in the AUT and the recalculation variable is set to FALSE so that for the remainder of that retrieval request the bandwidth re-allocation algorithm will not increase that connection's bandwidth (**630**). Then the recalculation of bandwidth allocation algorithm is invoked (**650**) which updates the AUT, the AUT is then used to provide parameters to the bandwidth allocator (**655**) and the monitoring loop resumes (**600**).

An event indicating a change in the relative priority of a transmission (**640**) may occur. The priority for that transmission is then updated in the AUT (**660**). Then the recalculation of bandwidth allocation algorithm is invoked (**650**) which updates the AUT, the AUT is then used to provide parameters to the bandwidth allocator (**655**) and the monitoring loop resumes (**600**).

A scheduled event may be set to occur periodically (**645**). This event is to handle any situation not handled by the other events. Then the recalculation of bandwidth allocation algorithm is invoked (**650**) which updates the AUT, the AUT is used to provide parameters to the bandwidth allocator (**655**) and the monitoring loop resumes (**600**).

Figure 7A is a flowchart of a procedure for dynamic bandwidth allocation by the server. The procedure begins by initializing several variables: MaxBW is set to the maximum bandwidth available to the server,

COUNT is set to the number of rows in the AUT (i.e., the number of current connections), SumOfPriorities is set to zero, and index I (a loop counter) is set to one (**700**). If index I is not greater than COUNT (**705**) then there are more rows to process in the AUT. At **710** the MaxBW is decreased by any difference between the allocated bandwidth and the utilized bandwidth. If the AUT recalculation variable for the current row is TRUE then the priority of the current row is added to the SumOfPriorities (**720**). This action prevents those connections that are being under-utilized from receiving more bandwidth which they have already demonstrated they cannot use. Then index I is incremented by one (**725**) and the loop continues at **705** until all the rows in the AUT have been processed.

Index I is re-initialized at **730** to one and another loop commences at **735**. While index I does not exceed COUNT (**735**), the recalculation variable of each row is checked **760.** If it is FALSE then the current AUT row has its allocated bandwidth set to equal its utilized bandwidth (**755**) thus reflecting the true state of the system. If it is TRUE, then the current AUT row allocated bandwidth variable is assigned the value of the ratio of the current row's priority to the SumOfPriorities and the utilized value is set to equal the allocated value (**765**). This assumes that the client connection can utilize the new bandwidth it has been allocated. If it cannot, then it will be detected and corrected via **Figure 6 at 625**. In either case, index I is incremented (**770**) and processing the remaining rows in the AUT continues at **735**. If all the rows have been processed (**735**) then the AUT has been completely updated and is ready for use by the bandwidth allocator in **Figure 6** at **655** and the process is terminated (**750**).

Figure 7B is a illustration depicting the result of one iteration of the dynamic bandwidth allocation procedure of **Figure 7A**. Assume a web server is transmitting an HTLM document and a JPG file to one client and a GIF file to another client. Using the bandwidth allocation algorithm described in **Figure 7A** and using the priority scheme of **Figure 4**, the sum of the priorities is 6 so the HTLM document will receive 4/6 (66.7%) of the bandwidth, and both the JPG file and GIF file will receive 1/6 (16.7%) of the bandwidth. Now assume that the second client can only utilize 10% of the total bandwidth (which was determined using the process in **Figure 6** at **625**). The initial state **780** is shown in rows **781, 782** and **783**. Note that **783** has unused bandwidth capacity of 6.7% of the server's total bandwidth. In order for this bandwidth to be used, the bandwidth re-allocation algorithm of **Figure 7A** is run again.

The results of the reallocation are shown in the final state **790**. Since the recalculation variable of the AUT row for the JPG file would have been set to FALSE, the sum of the priorities is now 5 and the proportional distribution of the spare bandwidth would be 4/5 for the HTML document **791** and 1/5 for the GIF document **792**. So, 4/5 of the 6.7% available bandwidth is re-allocated to the HTML document, resulting in a final bandwidth utilization of 72.0%. Repeating the process for the GIF documents lead to a final bandwidth utilization of 18.0%. The JPG file retains the 10.0% share it could use prior to the re-allocation.

Figure 8A is a database schema organized as an exemplary way for storing client browser-status priorities. Each browser has an ID **800**, a Status **810** and a Priority **815**. The row **820** has an ID of A, a status of "Has Focus" (i.e., is the user's active browser) and a high priority of 4. Browser ID B **821** does not have the focus but is visible on the screen and has a priority of 2. Browser ID C **823** does not have the focus and is not visible (perhaps minimized) and has a low priority of 1.

Figure 8B is a flowchart of a procedure for client-side control of bandwidth allocation. Similar to the algorithm of **Figure 7A**, this procedure utilizes the ratio of a process priority to that of the sum of the priorities of all active process. The MaxBW constant is initialized at **830** with the maximum bandwidth the client has available to manage. The priorities of the browsers in use are summed (**840**) and that sum is then used as the divisor of the individual browser priorities to determine the bandwidth to be allocated to each browser (**850**). Next, the bandwidth is allocated, e.g. by controlling the number of packets acknowledged to the server to obtain the desired throughput rate (**860**) (as described in **Figure 6** at **625**) and the process terminates (**870**).

Figure 9 is a flowchart of a procedure for changing the priority of a connection after a fixed amount of data has been transmitted. As an alternative or a supplement to the preferred embodiment, an HTML file could be assigned a high priority only during the transmission of the first N KB. This approach might be used when only the first screen or part of the first screen of text must be delivered as rapidly as possible. The process begins by initializing N to the number of KB to transmit at high priority (**900**). Then the New Request event (**910**) (**Figure 6** at **605**) is triggered. The number of KB transmitted is monitored (**920**) and when the number transmitted equals N (**930**) the AUT is updated to reflect a lower priority by triggering the Change Priority event (**950**) (**Figure 6** at **640**).

Figure 10A is a database schema organized as an exemplary way for storing a value representing the variable amount of data a specific file needs have transmitted at high priority. As another alternative or supplement to the preferred embodiment, an HTML file could be examined (e.g., using a browser) to determine the number of bytes necessary to render the first page. This number of bytes would then be stored (**1005**) in a database along with the HTML file name **1000**. The database rows **1006, 1007** and **1008** are examples of the name and byte tuples required.

Figure 10B is a flowchart of a procedure for changing the priority of a connection after the variable amount of data indicated in **Figure 10A** has been transmitted. The variable N is set, via a database lookup of the file

name, to the number of bytes that need to be transmitted with high priority **1010**. The New Request event is triggered (**1020**) (**Figure 6** at **605**) and the number of bytes transmitted is monitored (**1030**). When the number of bytes transmitted equals N (**1040**) the Change Priority event is triggered (**1060**) (**Figure 6** at **640**) which then updates the AUT table and begins the bandwidth re-allocation process and this process is terminated (**1070**).

Figure 11A is a database schema organized as an exemplary way for storing a list of customer passwords and a corresponding priority multiplier. As another supplement or alternative to the preferred embodiment, the priority given to web pages could be based on information about the person requesting them. For example, valued customers can be given higher priority. When implemented in a log-in type website, a list of passwords that have higher than normal priority could be kept in the form of the tuple Customer Password **1100** and Priority Multiplier **1105**. As rows **1106, 1107** and **1108** show, the multiplier can be different based on how valued the customer is. In another approach, a list of network addresses of valued customers is maintained and checked against the address of client's connections to the server to determine priorities.

Figure 11B is a flowchart of a procedure for increasing the priority of a connection using the information contained within **Figure 11A**. A customer accesses a website and enters his password (**1110**). If the password is in the priority database of **Figure 11A** (**1120**) then the priority for the document requested is set to the standard priority for that type of document multiplied by the priority multiplier **1130**. For example, if an HTLM document has a priority of 4 and the multiplier is 2 the new priority would be 8. Then the New Request event is triggered (**1140**) (**Figure 6** at **605**) and this process is terminated (**1140**).

Figure 12A is a database scheme organized as an exemplary way for storing a list of documents and their associated priority multipliers. As another supplement or alternative to the preferred embodiment, the priority given to web pages could be based on content of the pages themselves and their value to the web page owner. Providing an order form on the user's screen may be deemed to have a higher priority than delivering product information. The tuples of HTLM page name **1200** and Priority Multiplier **1205** can be stored in the database. As rows **1206, 1207** and **1208** show, the multiplier can be different based on how important a particular HTML document is.

Figure 12B is a flowchart of a procedure for increasing the priority of a connection using the information contained within **Figure 12A**. The user requests an HTML page (**1210**). If the page name is found in the priority database (**1220**) then the transmission priority becomes the normal transmission priority multiplied by the priority multiplier (**1230**). Then the New Request event is triggered (**1240**) (**Figure 6** at **605**) and this process is terminated (**1250**).

There has thus been described a communication system in which communication resource allocated by either servers or clients can be adapted based on priority of various types. As a result, user satisfaction with the network is enhanced by obtaining desired information in a prompt fashion and server and client resources are prioritized to enhance throughput of the network.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Claims

1. Computer apparatus for allocating communications bandwidth to a plurality of user connections, comprising:

   a. a bus;
   b. at least one communications interface connected to said bus;
   c. a processor connected to said bus, said processor configured to allocate communications bandwidth to said user connections serviced by said at least one communications interface based on at least one set of priorities.

2. The apparatus of claim 1, in which one set of priorities comprises priorities based on type of information being retrieved.

3. The apparatus of claim 2 in which said type of information includes at least one of information in HTML format, information in a style sheet format, information in a GIF image format and information in a JPEG image format.

4. The apparatus of claim 1, in which one set of priorities comprises priorities based on how fast user connections can receive information.

5. The apparatus of claim 1, in which one set of priorities comprises priorities based on which part of a document is being transmitted.

6. The apparatus of claim 1, in which one set of priorities comprises priorities based on user identity.

7. The apparatus of claim 1, in which one set of priorities comprises priorities based on stored indicia indicating importance of the document.

8. Computer apparatus for allocating communications bandwidth to a plurality of server connections, comprising:

a. a bus;
b. at least one communications interface connected to said bus;
c. a processor connected to said bus, said processor configured to allocate communications bandwidth to server connections serviced by said at least one communications interface based on at least one set of priorities.

9. The apparatus of claim 8, in which one set of priorities comprises priorities based on the state of application processes running on said processor.

10. The apparatus of claim 9, in which the state of application processes comprises the foreground or background state of a process.

11. The apparatus of claim 9, in which the state of application processes comprises the degree to which a window in which a process is running is ready for use by a user.

12. A method of operating a server on a network, comprising the step of:

a. providing an element for allocating communications bandwidth at a server to a plurality of user connections based on at least one set of priorities.

13. The method of claim 12 in which said set of priorities includes at least one of: type of information being retrieved, how fast user connections can receive information, which part of a document is being transmitted, user identity and stored indicia indicating importance of the document.

14. The method of claim 12 in which bandwidth is allocated to a user connection based on the ratio of priority that user connection bears to the sum of priorities of all user connections.

15. The method of claim 13 in which bandwidth allocation is recalculated on an event driven basis.

16. The method of claim 14 in which events triggering recalculation include at least one of: arrival of a new request for retrieval, finishing sending information in response to a retrieval request, cancellation of a retrieval request, detection of the inability of a user connection to use all of the bandwidth allocated to it, a change of priority and timeout of a timer.

17. A method of controlling communications by a process on a computer connected to a network, comprising the step of:

a. providing an element for allocating communications bandwidth to a plurality of server connections in use by said process based on at least one set of priorities.

18. The method of claim 17 in which said priorities are based on the state of application processes running on said processor.

19. A communications system, comprising:

a. a network;
b. at least one server connected to said network; and
c. at least one computer running at least one process connected to said network,

in which said at least one server or said at least one computer allocates bandwidth to a plurality of network connections based on at least one set of priorities.

20. The system of claim 19 in which said set of priorities includes at least one of: type of information being retrieved, how fast user connections can receive information, which part of a document is being transmitted, user identity, stored indicia indicating importance of the document and the state of application processes running on said computer.

21. A computer program product, comprising:

a. a memory medium;
b. a computer program, stored on said memory medium, said computer program comprising instructions for allocating communications bandwidth at a server to a plurality of user connections based on at least one set of priorities.

22. A computer program product, comprising:

a. a memory medium;
b. a computer program, stored on said memory medium, said computer program comprising instructions for allocating communications bandwidth to communications connections based on at least one set of priorities.

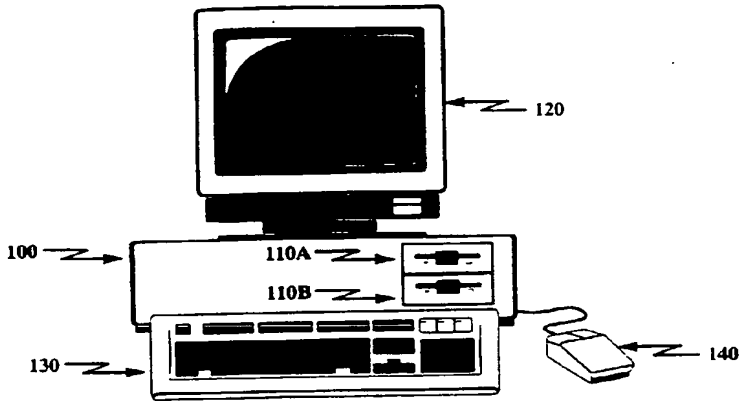

Figure 1A

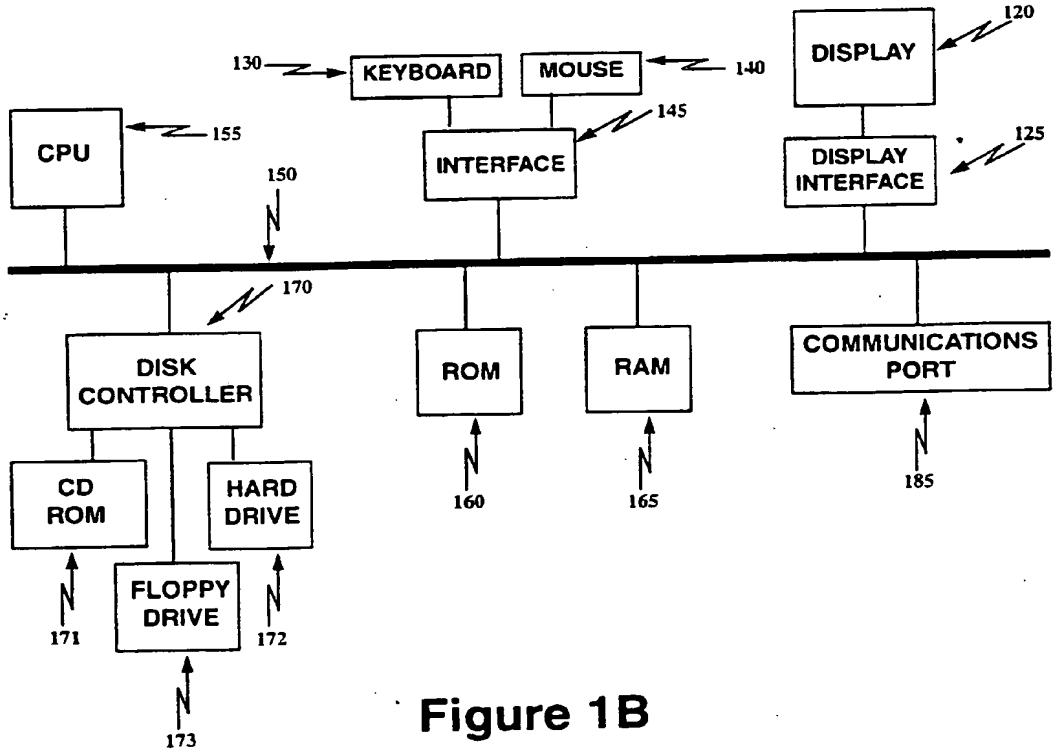

Figure 1B

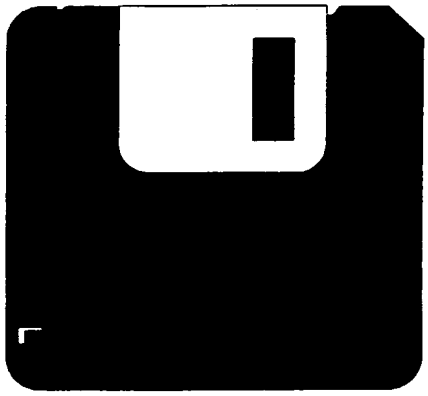

Figure 1C

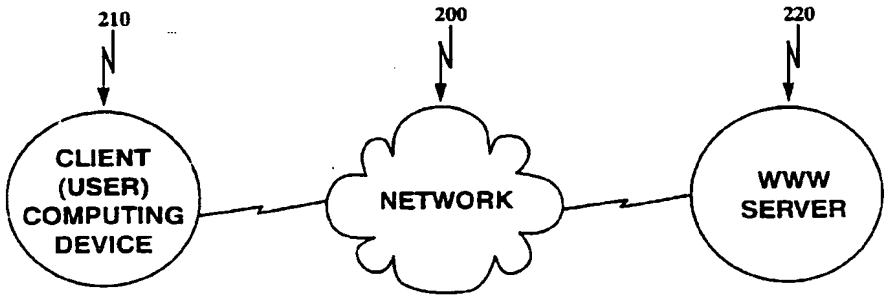

Figure 2A

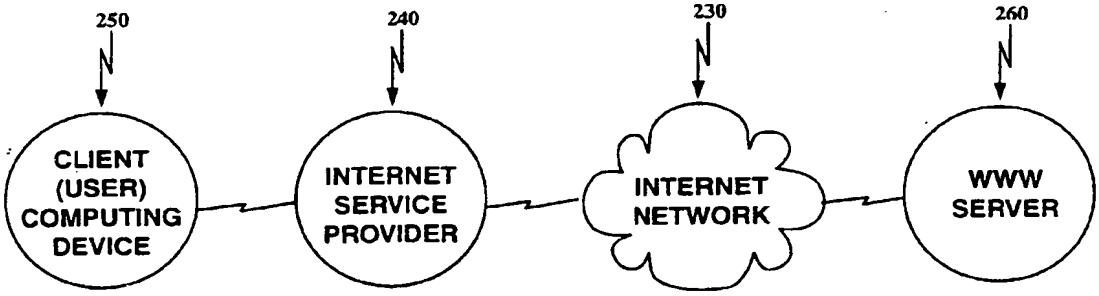

Figure 2B

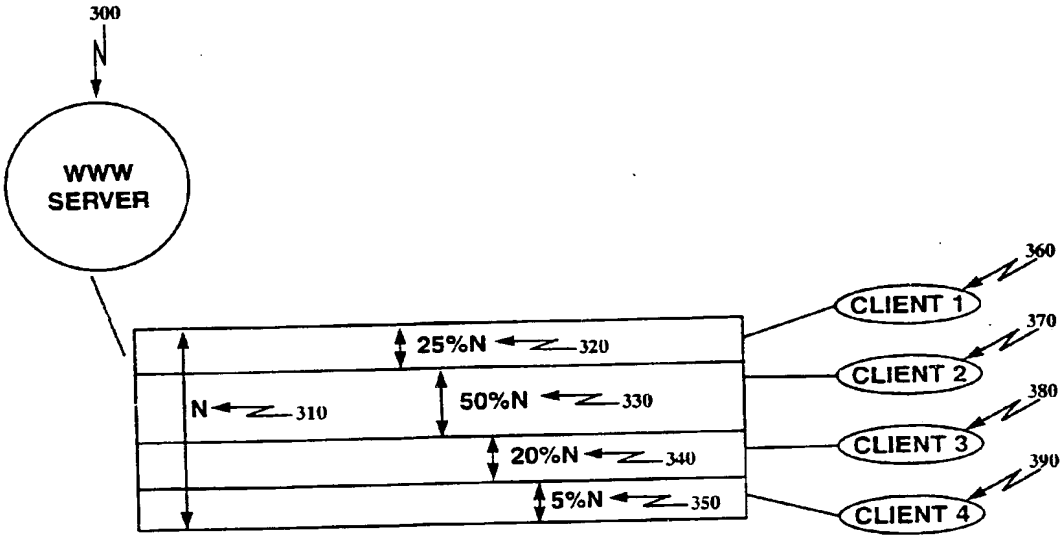
300
N
WWW SERVER
25%N
320
N
310
50%N
330
20%N
340
5%N
350
360
CLIENT 1
370
CLIENT 2
380
CLIENT 3
390
CLIENT 4

Figure 3

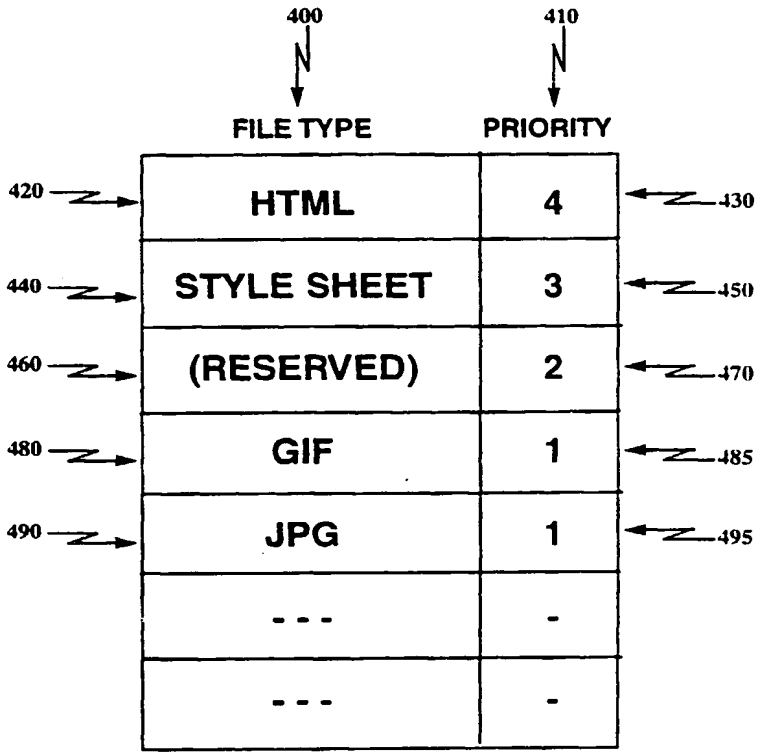
400
410
FILE TYPE
PRIORITY
420
HTML
4
430
440
STYLE SHEET
3
450
460
(RESERVED)
2
470
480
GIF
1
485
490
JPG
1
495
- - -
-
- - -
-

Figure 4

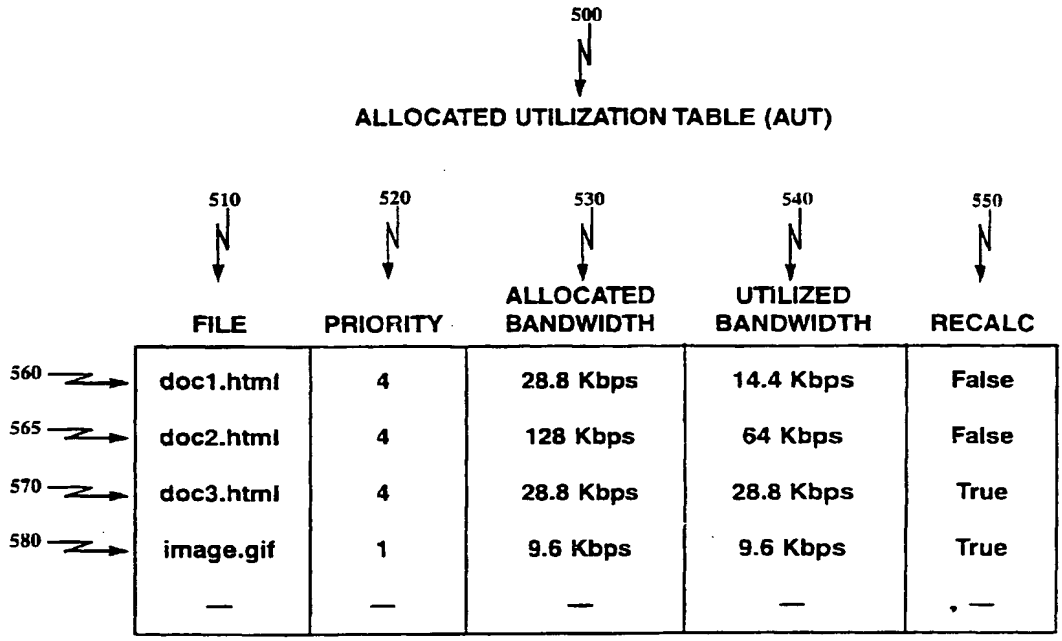
500
ALLOCATED UTILIZATION TABLE (AUT)
510
520
530
540
550
FILE
PRIORITY
ALLOCATED BANDWIDTH
UTILIZED BANDWIDTH
RECALC
560
doc1.html
4
28.8 Kbps
14.4 Kbps
False
565
doc2.html
4
128 Kbps
64 Kbps
False
570
doc3.html
4
28.8 Kbps
28.8 Kbps
True
580
image.gif
1
9.6 Kbps
9.6 Kbps
True

Figure 5

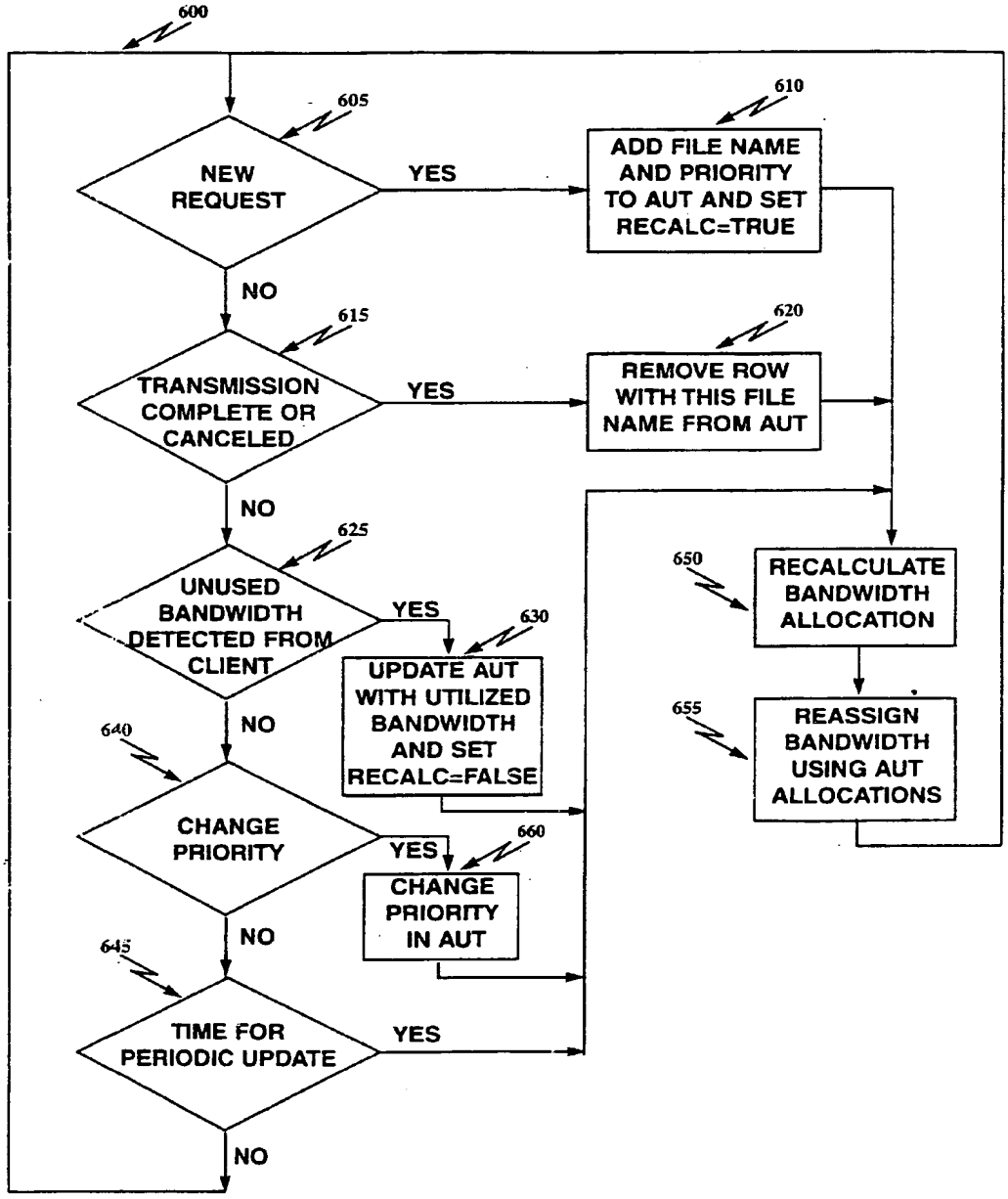
600
605
NEW REQUEST
YES
610
ADD FILE NAME AND PRIORITY TO AUT AND SET RECALC=TRUE
NO
615
TRANSMISSION COMPLETE OR CANCELED
YES
620
REMOVE ROW WITH THIS FILE NAME FROM AUT
NO
625
UNUSED BANDWIDTH DETECTED FROM CLIENT
YES
630
UPDATE AUT WITH UTILIZED BANDWIDTH AND SET RECALC=FALSE
650
RECALCULATE BANDWIDTH ALLOCATION
655
REASSIGN BANDWIDTH USING AUT ALLOCATIONS
NO
640
CHANGE PRIORITY
YES
660
CHANGE PRIORITY IN AUT
NO
645
TIME FOR PERIODIC UPDATE
YES
NO

Figure 6

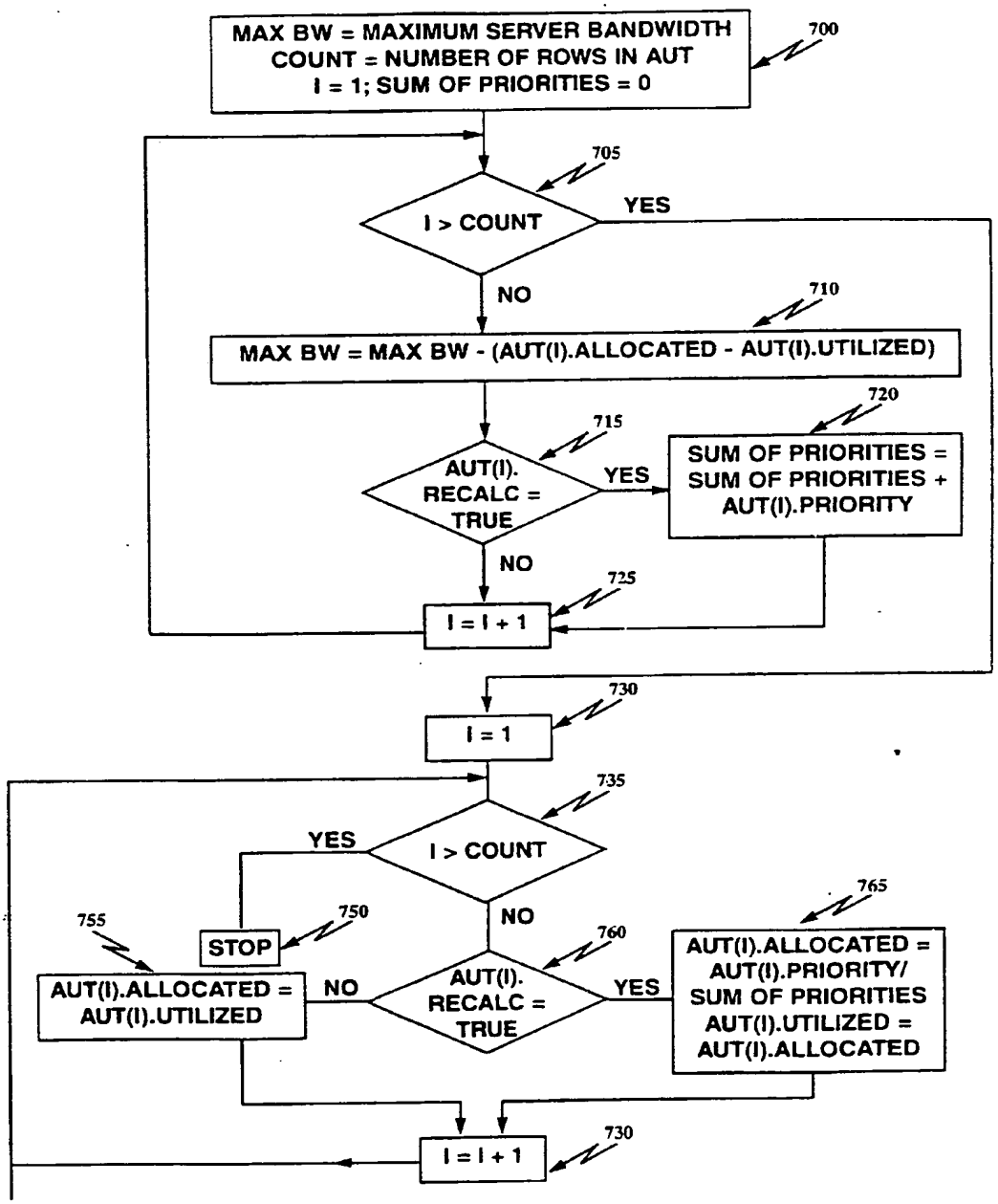
MAX BW = MAXIMUM SERVER BANDWIDTH
COUNT = NUMBER OF ROWS IN AUT
I = 1; SUM OF PRIORITIES = 0
700
705
I > COUNT
YES
NO
710
MAX BW = MAX BW - (AUT(I).ALLOCATED - AUT(I).UTILIZED)
720
715
AUT(I). RECALC = TRUE
YES
SUM OF PRIORITIES = SUM OF PRIORITIES + AUT(I).PRIORITY
NO
725
I = I + 1
730
I = 1
735
YES
I > COUNT
NO
765
755
750
STOP
760
AUT(I).ALLOCATED = AUT(I).UTILIZED
NO
AUT(I). RECALC = TRUE
YES
AUT(I).ALLOCATED = AUT(I).PRIORITY/ SUM OF PRIORITIES
AUT(I).UTILIZED = AUT(I).ALLOCATED
730
I = I + 1

Figure 7A

780

INITIAL CONDITION

	FILE TYPE	PRIORITY	ALLOCATED BANDWIDTH RATIO	ALLOCATED BANDWIDTH PERCENT	UTILIZED BANDWIDTH PERCENT	UNUSED BANDWIDTH PERCENT
781	HTML	4	4/6	66.7%	66.7%	0%
782	GIF	1	1/6	16.7%	16.7%	0%
783	JPG	1	1/6	16.7%	10.0%	6.7%

790

FINAL CONDITION AFTER RECALCULATION

	FILE TYPE	PRIORITY	ALLOCATED BANDWIDTH RATIO	ORIGINAL ALLOCATED BANDWIDTH PERCENT	ADDITIONAL BANDWIDTH ADDED PERCENT	FINAL BANDWIDTH PERCENT
791	HTML	4	4/5	66.7%	4/5 x 6.7% = 5.3	72.0%
792	GIF	1	1/5	16.7%	1/5 x 6.7% = 1.3	18.0%
793	JPG	1	N/A			10%

Figure 7B

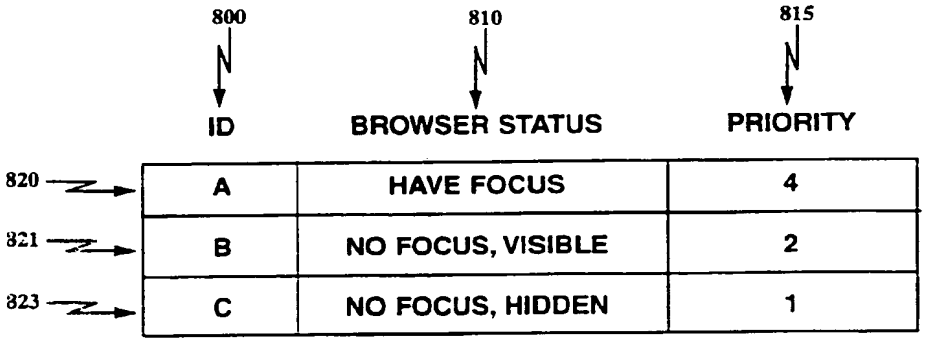

Figure 8A

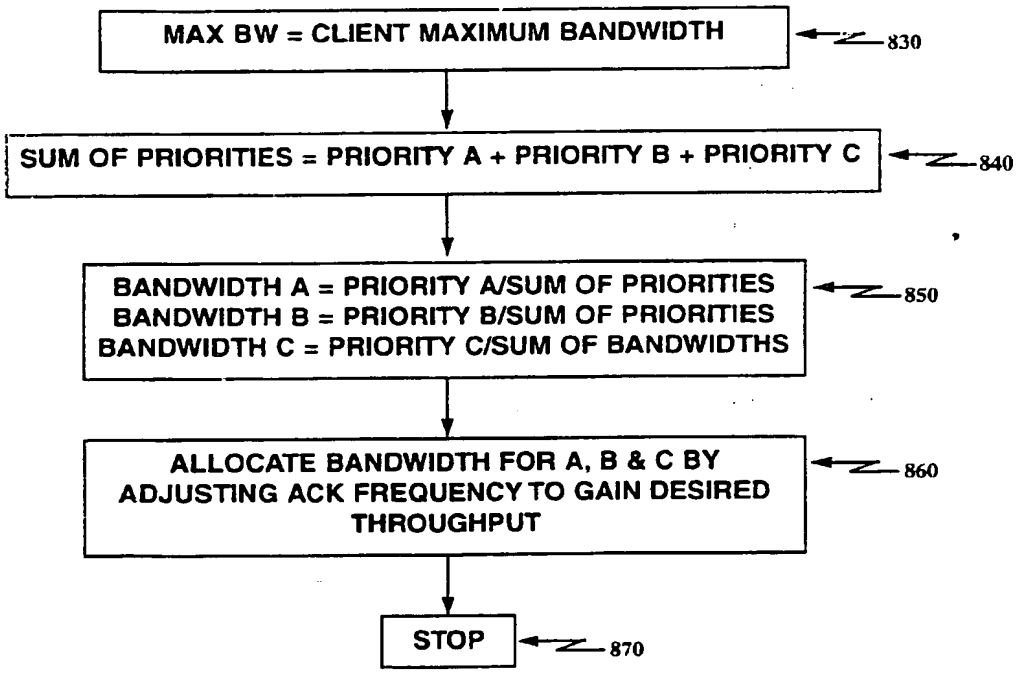

Figure 8B

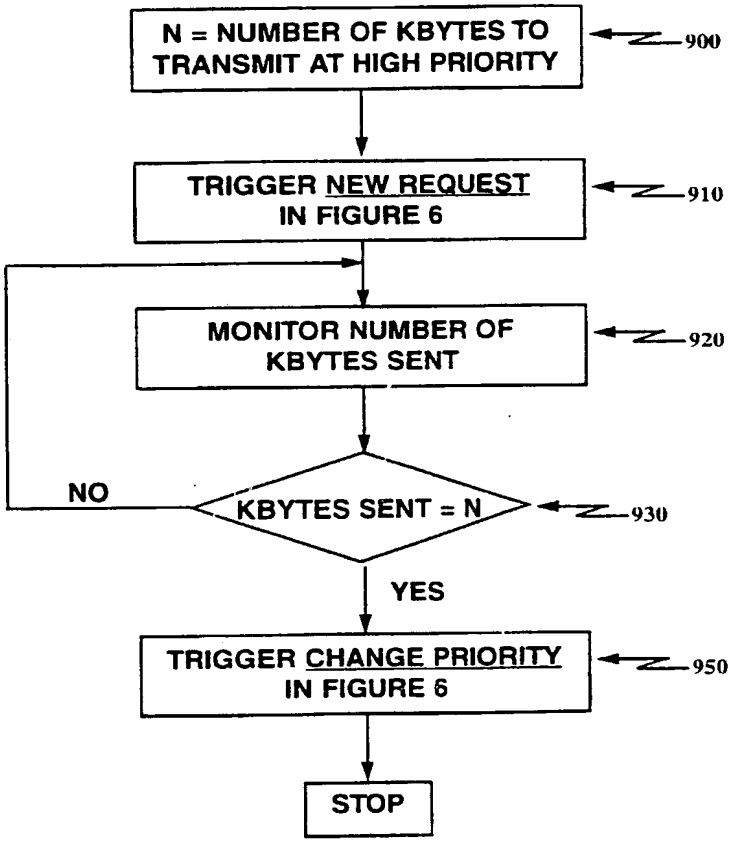
N = NUMBER OF KBYTES TO TRANSMIT AT HIGH PRIORITY
900
TRIGGER NEW REQUEST IN FIGURE 6
910
MONITOR NUMBER OF KBYTES SENT
920
NO
KBYTES SENT = N
930
YES
TRIGGER CHANGE PRIORITY IN FIGURE 6
950
STOP

Figure 9

	1000 HTML FILE NAME	1005 KBYTES NEEDED TO RENDER PAGE 1
1006	doc1.html	10
1007	doc2.html	15
1008	doc3.html	13

Figure 10A

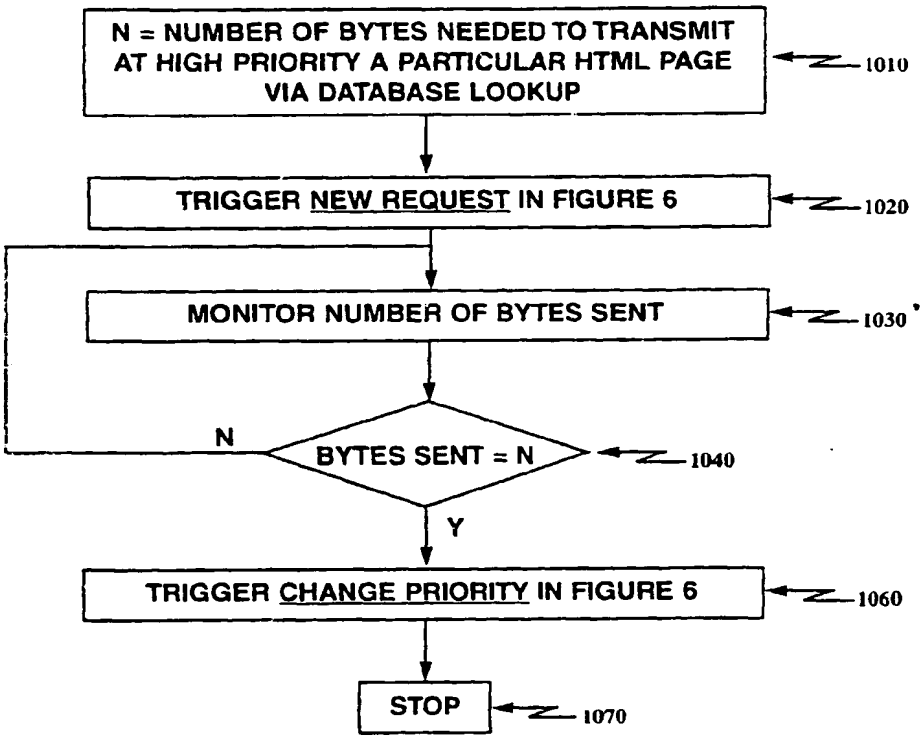

Figure 10B

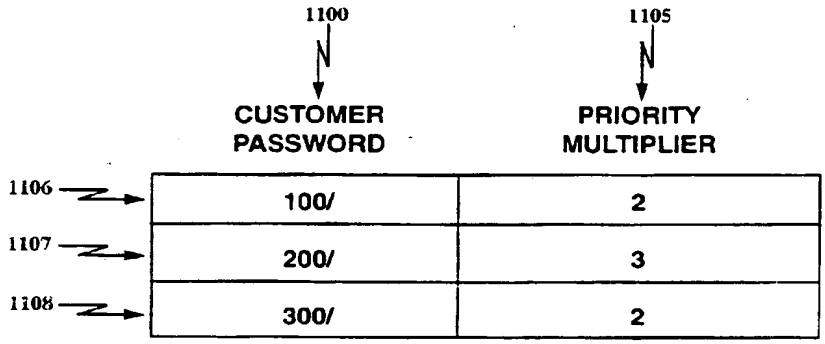

Figure 11A

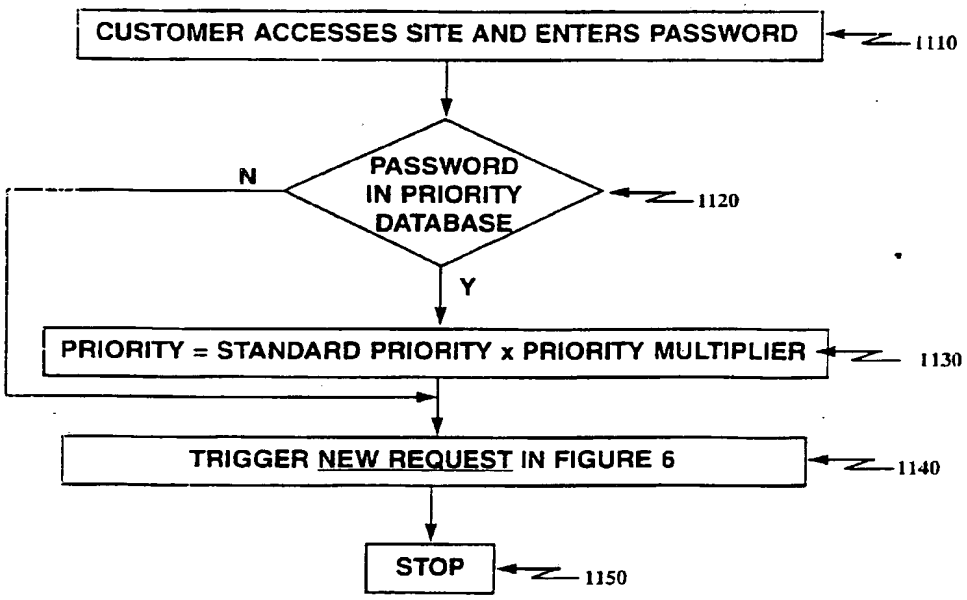

Figure 11B

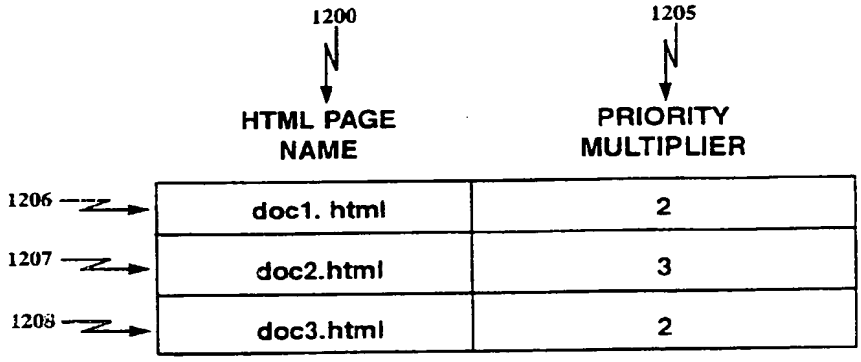

Figure 12A

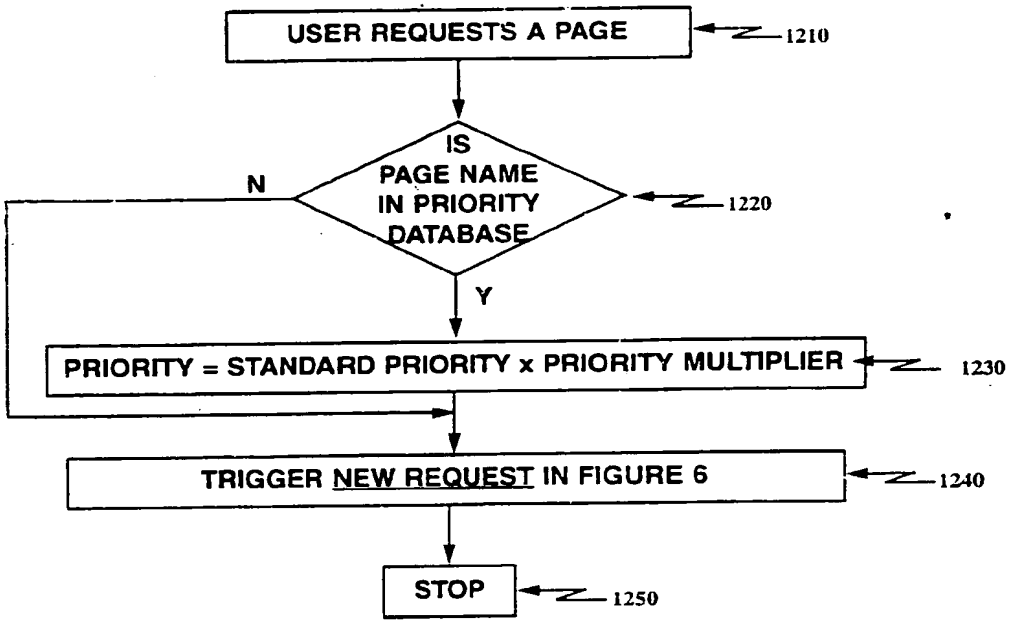

Figure 12B

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 881 808 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
05.04.2000 Bulletin 2000/14

(43) Date of publication A2:
02.12.1998 Bulletin 1998/49

(21) Application number: **98303419.0**

(22) Date of filing: **30.04.1998**

(51) Int Cl.[7]: **H04L 29/06**, H04L 12/56

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **30.05.1997 US 865962**

(71) Applicant: **SUN MICROSYSTEMS, INC.**
Palo Alto, California 94043 (US)

(72) Inventor: **Nielsen, Jakob**
Atherton, CA 94027 (US)

(74) Representative: **Read, Matthew Charles et al**
Venner Shipley & Co.
20 Little Britain
London EC1A 7DH (GB)

(54) Latency-reducing bandwidth-prioritization for network servers and clients

(57) Communications bandwidth available to network servers and computers running client processes is allocated among connections available to those devices based on sets of priorities. Those priorities include type of information being retrieved, how fast user connections can receive information, which part of a document is being transmitted, user identity, stored indicia indicating importance of the document and the state of application processes running on said computer. Bandwidth is reallocated on an event driven basis upon arrival of a new request for retrieval, finishing sending information in response to a retrieval request, cancellation of a retrieval request, detection of the inability of a user connection to use all of the bandwidth allocated to it, a change of priority and timeout of a timer.

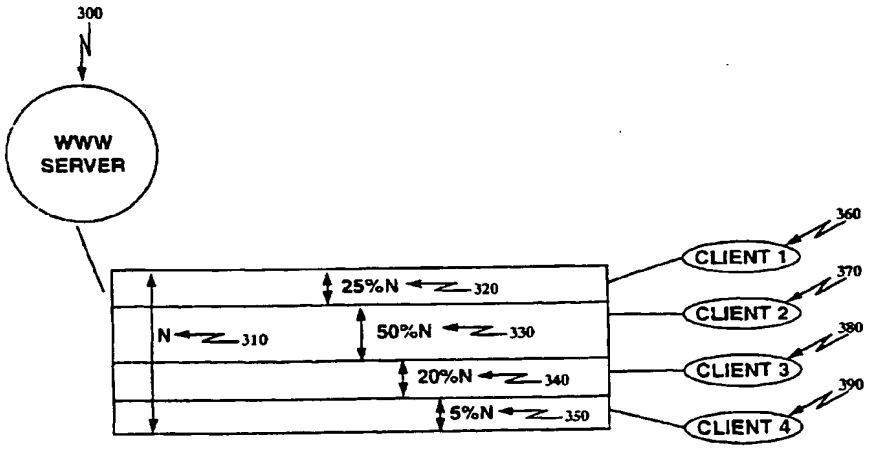

Figure 3

EP 0 881 808 A3

Printed by Jouve, 75001 PARIS (FR)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 3419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	EP 0 632 671 A (IBM) 4 January 1995 (1995-01-04) * abstract * * column 1, line 32 - column 3, line 17 * * column 4, line 7 - column 8, line 58 * * column 12, line 11 - column 14, line 36 * * figures 1,2,4 *	1,2,8. 12,13, 17,19-22 3-7, 9-11, 14-16,18	H04L29/06 H04L12/56
Y	GB 2 301 260 A (IBM) 27 November 1996 (1996-11-27) * abstract * * page 7, line 33 - page 8, line 10 *	3	
A	US 5 414 697 A (OSAKI YOSHIRO) 9 May 1995 (1995-05-09) * abstract * * column 1, line 6 - column 7, line 21; figures 3,4 *	1,2,8, 12,13, 17,19-22	
Y	US 5 153 877 A (ESAKI HIROSHI ET AL) 6 October 1992 (1992-10-06) * abstract * * column 1, line 7-50 * * column 2, line 59 - column 3, line 41 *	4	

-/--

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H04L
G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 2000	Lievens, K

CATEGORY OF CITED DOCUMENTS

X particularly relevant if taken alone
Y particularly relevant if combined with another document of the same category
A technological background
O non-written disclosure
P intermediate document

T theory or principle underlying the invention
E earlier patent document, but published on or after the filing date
D document cited in the application
L document cited for other reasons

& member of the same patent family, corresponding document

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Application Number
EP 98 30 3419

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 3419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	SHRIKUMAR H ET AL: "Thinternet: life at the end of a tether" COMPUTER NETWORKS AND ISDN SYSTEMS,NL,NORTH HOLLAND PUBLISHING. AMSTERDAM, vol. 27, no. 3, page 375-385 XP004037970 ISSN: 0169-7552	5	
A	* page 375, line 1 - page 378, left-hand column, line 35 * * page 379, right-hand column, line 38 - page 382, left-hand column, line 4 *	7,9-11, 18	
Y	US 4 642 758 A (TENG ALBERT Y) 10 February 1987 (1987-02-10) * column 1, line 11 - column 2, line 26 * * column 7, line 5-48 * * column 10, line 20-61 * * figures 7-10 *	6	
Y	US 5 428 778 A (BROOKES CYRIL) 27 June 1995 (1995-06-27) * abstract * * column 1, line 9 - column 3, line 35 * * column 5, line 20 - column 7, line 61 *	7	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	CHEN I -R ET AL: "THRESHOLD-BASED ADMISSION CONTROL POLICIES FOR MULTIMEDIA SERVERS" COMPUTER JOURNAL,GB,OXFORD UNIVERSITY PRESS, SURREY, vol. 39, no. 9, page 757-766 XP000720396 ISSN: 0010-4620 * abstract * * page 757, left-hand column, line 1 - page 758, right-hand column, line 2 *	1,6	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 2000	Lievens, K

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 98 30 3419

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-3,8,12,13,17,19-22

   Method and apparatus for allocating bandwidth to a plurality of user connections according to priorities.

2. Claims: 1,4-7

   Apparatus for adapting the speed of receiving data to the capabilities of the receiver and to contextual information.

3. Claims: 8,9-11,17-18

   Method and apparatus for using multiple application processes when accessing the internet.

4. Claims: 12-16

   Method of recalculating on an event-driven basis the ratios for assigning bandwidth.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 3419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 6)
Y	WO 95 08793 A (VIRTUAL UNIVERSE CORP) 30 March 1995 (1995-03-30) * abstract * * page 2, line 5 - page 3, line 16 * * page 4, line 15-24 * * page 8, line 19 - page 9, line 37 *	9-11,18	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 185 (P-710), 31 May 1988 (1988-05-31) & JP 62 293310 A (MITSUBISHI ELECTRIC CORP), 19 December 1987 (1987-12-19) * abstract *	10	
Y	BENNETT J C R ET AL: "WF2Q: WORST-CASE FAIR WEIGHTED FAIR QUEUEING" PROCEEDINGS OF INFOCOM,US,LOS ALAMITOS, IEEE COMP. SOC. PRESS, vol. CONF. 15, page 120-128 XP000622302 ISBN: 0-8186-7293-5 * page 120, left-hand column * * page 121, left-hand column, line 40 - right-hand column, line 30 *	14	
Y	EP 0 693 840 A (DIGITAL EQUIPMENT CORP) 24 January 1996 (1996-01-24) * abstract * * page 2, line 21 - page 3, line 24 * * page 5, line 9-46 * * page 8, line 49 - page 10, line 9 *	15,16	
	-/--		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 2000	Lievens, K

CATEGORY OF CITED DOCUMENTS

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T theory or principle underlying the invention
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L document cited for other reasons

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 3419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	KANELLOPOULOS D N ET AL: "C-MACSE: A NEW CONNECTION ESTABLISHMENT PROTOCOL FOR MULTIMEDIA COMMUNICATIONS RESIDING AT THE OSI APPLICATION LAYER ADOPTING A COMPREHENSIVE QOS APPROACH" NL,AMSTERDAM, IOS, page 141-150 XP000754559 ISBN: 90-5199-290-4 * abstract * * page 142, line 12 - page 144, line 40 *	1,14-16	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 2000	Lievens, K

CATEGORY OF CITED DOCUMENTS

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T theory or principle underlying the invention
E earlier patent document, but published on, or after the filing date
D document cited in the application
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 3419

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05-01-2000

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		US 5968128 A	19-10-1999

EPO FORM P0459

For more details about this annex see Official Journal of the European Patent Office, No. 12/82